

U.S. PATENT APPLICATION

Title: SEMICONDUCTOR PACKAGE WITH ENHANCED
ELECTRICAL AND THERMAL PERFORMANCE AND
METHOD FOR FABRICATING THE SAME

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SEMICONDUCTOR PACKAGE WITH ENHANCED ELECTRICAL AND THERMAL PERFORMANCE AND METHOD FOR FABRICATING THE SAME

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FIELD OF THE INVENTION

The present invention relates to semiconductor packages and fabrication methods thereof, and more particularly, to a BGA (ball grid array) package with enhanced electrical and thermal performance, and a method for fabricating the BGA package.

BACKGROUND OF THE INVENTION

10 BGA (ball grid array) is an advanced type of semiconductor packaging technology, which is characterized by the use of a substrate as a chip carrier whose front surface is used for mounting one or more semiconductor chips and whose back surface is provided with a plurality of array-arranged solder balls. During a SMT (surface mount technology) process, a BGA package can be mechanically bonded and electrically coupled to an external device
15 such as a printed circuit board (PCB) by means of these solder balls.

Patents related to BGA technology include, for example, U.S. Patent No. 5,851,337 entitled "METHOD OF CONNECTING TEHS ON PBGA AND MODIFIED CONNECTING STRUCTURE". This patent is characterized by the use of a ground circuit for connecting a heat spreader to a substrate to help enhance grounding effect of a BGA package. One drawback to this patent, however, is that it is unsuitably used for packaging
20 semiconductor chips having a great number of power and ground pads.

A conventional solution to the foregoing problem is depicted with reference to FIGs. 1A and 1B. As shown, an exemplified BGA package comprises: a substrate 100, at least a semiconductor chip 110, a power-connecting heat spreader 120, a ground-

connecting heat spreader 130, a plurality of sets of bonding wires 141, 142, 143, an encapsulation body 150, and a plurality of array-arranged solder balls 160.

The substrate 100 has a front surface 100a and a back surface 100b, and is formed with a plurality of electrically-conductive vias 101a, 101b, 101c at predetermined positions, including power vias 101a, ground vias 101b and I/O (input/output) vias 101c, which are adapted to penetrate through the substrate 100.

The semiconductor chip 110 has an active surface 110a and an inactive surface 110b. The active surface 110a is formed with a plurality of bond pads 111a, 111b, 111c, including power pads 111a, ground pads 111b and I/O pads 111c. This active surface 110a of the semiconductor chip 110 is further formed with a power plane 112a and a ground plane 112b, wherein the power plane 112a is electrically connected to the power pads 111a by a first set of bonding wires 141, and the ground plane 112b is electrically connected to the ground pads 111b by a second set of bonding wires 142. Further, the I/O pads 111c are electrically connected by a third set of bonding wires 143 to the I/O vias 101c on the front surface 100a of the substrate 100.

The power-connecting heat spreader 120 is integrally formed by a support portion 121, an overhead portion 122 and a downward-extending portion 123. The power-connecting heat spreader 120 is mounted over the substrate 100 to partly cover the semiconductor chip 110, wherein the support portion 121 is electrically bonded to the power vias 101a of the substrate 100, and the downward-extending portion 123 is electrically bonded to the power plane 112a on the semiconductor chip 110, allowing the overhead portion 122 to be elevated in position above the semiconductor chip 110 by the support portion 121 and the downward-extending portion 123. The power-connecting heat spreader 120 is used to connect power to the semiconductor chip 110, and to dissipate heat generated by the semiconductor chip 110 during operation.

Similarly, the ground-connecting heat spreader 130 is composed of a support portion 131, an overhead portion 132 and a downward-extending portion 133. The ground-

connecting heat spreader 130 is mounted over the substrate 100 to partly cover the semiconductor chip 110, wherein the support portion 131 is electrically bonded to the ground vias 101b of the substrate 100, and the downward-extending portion 133 is electrically bonded to the ground plane 112b on the semiconductor chip 110, allowing the overhead portion 132 to be elevated in position above the semiconductor chip 110 by the support portion 131 and the downward-extending portion 133. The ground-connecting heat spreader 130 is used to connect the semiconductor chip 110 to ground, and to dissipate heat generated by the semiconductor chip 110 during operation.

The encapsulation body 150 is formed to encapsulate the front surface 100a of the substrate 100, the semiconductor chip 110, the power-connecting heat spreader 120, and the ground-connecting heat spreader 130. In view of power transmission and grounding purposes, the power-connecting heat spreader 120 and the ground-connecting heat spreader 130 are preferably not exposed to outside of the encapsulation body 150.

The array-arranged solder balls 160 are implanted on the back surface 100b of the substrate 100, including a plurality of power balls 161 electrically connected to the power vias 101a, a plurality of ground balls 162 electrically connected to the ground vias 101b, and a plurality of I/O balls 163 electrically connected to the I/O vias 101c.

By the above structure as illustrated in FIG. 1A, power can be externally supplied to the semiconductor chip 110 successively via the power balls 161, the power vias 101a, the power-connecting heat spreader 120, the power plane 112a, the bonding wires 141, and the power pads 111a. Moreover, the semiconductor chip 110 can be connected to ground successively via the ground pads 111b, the bonding wires 142, the ground plane 112b, the ground-connecting heat spreader 130, the ground vias 101b, and the ground balls 162. Further, the semiconductor chip 110 can transfer I/O signals via the I/O pads 111c, the bonding wires 143, the I/O vias 101c, and the I/O balls 163.

One drawback to the forgoing BGA package, however, is that, since the ground-connecting heat spreader 130 only covers part of the semiconductor chip 110, it would not

be able to provide good EMI (electromagnetic interference) shielding effect for the semiconductor chip 110 during operation.

Moreover, since both the power-connecting heat spreader 120 and the ground-connecting heat spreader 130 are completely enclosed by the encapsulation body 150, they 5 may not provide satisfactory heat-dissipation efficiency for the packaged semiconductor chip 110.

SUMMARY OF THE INVENTION

An objective of this invention is to provide a semiconductor package with enhanced electrical and thermal performance, which provides good EMI (electromagnetic 10 interference) shielding effect.

Another objective of this invention is to provide a semiconductor package with enhanced electrical and thermal performance, by which satisfactory heat-dissipation efficiency is achieved.

A further objective of this invention is to provide a semiconductor package with 15 enhanced electrical and thermal performance, wherein the semiconductor package is cost-effectively fabricated.

In accordance with the above and other objectives, the present invention proposes a BGA semiconductor package and a method for fabricating the same.

The BGA semiconductor package of the invention comprises: a substrate having a 20 front surface and a back surface opposed to the front surface; at least a chip having an active surface and an inactive surface opposed to the active surface, wherein the active surface is formed with a power plane and a ground plane, and the inactive surface is mounted on the front surface of the substrate; a power-connecting heat spreader adapted to entirely cover the chip, and electrically bonded to the front surface of the substrate and the 25 power plane on the chip; a ground-connecting heat spreader positioned in elevation above the power-connecting heat spreader, and adapted to be electrically bonded to the front

surface of the substrate and the ground plane on the chip; an encapsulation body for encapsulating the front surface of the substrate, the chip, the power-connecting heat spreader and the ground-connecting heat spreader; and a plurality of solder balls implanted on the back surface of the substrate.

5 The above package structure is characterized by the use of a specially-designed set of power-connecting heat spreader and ground-connecting heat spreader, which are each electrically connected to and structured to entirely cover an underlying chip. Thereby, the power-connecting heat spreader allows external power to be efficiently supplied to the chip, and the ground-connecting heat spreader would provide good EMI shielding effect
10 for allowing the chip to improve its electrical performance during operation. Further, a top surface of the ground-connecting heat spreader is adapted to be exposed to outside of an encapsulation body that encapsulates the chip, thereby helping enhancing heat-dissipation efficiency for the package structure.

BRIEF DESCRIPTION OF THE DRAWINGS

15 The present invention can be more fully understood by reading the following detailed description of the preferred embodiments, with reference made to the accompanying drawings, wherein:

FIGs. 1A-1B (PRIOR ART) are schematic diagrams used to depict the structure of a conventional BGA package; and

20 FIGs. 2A-2E are schematic diagrams used to depict a preferred embodiment of a semiconductor package of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 The following description is made with reference to FIGs. 2A-2E, for detailing preferred embodiments of a BGA (ball grid array) semiconductor package proposed in the present invention.

As shown in FIG. 2E, the BGA semiconductor package of the invention comprises: a substrate 200 having a front surface 200a and a back surface 200b opposed to the front surface 200a; at least a chip 210 having an active surface 210a and an inactive surface 210b opposed to the active surface 210a, wherein the active surface 210a is formed with a power plane 212a and a ground plane 212b, and the inactive surface 210b is mounted on the front surface 200a of the substrate 200; a power-connecting heat spreader 220 adapted to entirely cover the chip 210, and electrically bonded to the front surface 200a of the substrate 200 and the power plane 212a on the chip 210; a ground-connecting heat spreader 230 positioned in elevation above the power-connecting heat spreader 220, and adapted to be electrically bonded to the front surface 200a of the substrate 200 and the ground plane 212b on the chip 210; an encapsulation body 250 for encapsulating the front surface 200a of the substrate 200, the chip 210, the power-connecting heat spreader 220 and the ground-connecting heat spreader 230; and a plurality of solder balls 260 implanted on the back surface 200b of the substrate 200.

The above BGA semiconductor package can be fabricated by the following steps as illustrated in FIGs. 2A to 2E.

Referring to FIG. 2A, the first step is to prepare a substrate 200, a chip 210, a power-connecting heat spreader 220, and a ground-connecting heat spreader 230.

The substrate 200 has a front surface 200a and a back surface 200b, with a plurality of power vias 201a, ground vias 201b and I/O (input/output) vias 201c being formed to penetrate through the substrate 200.

The chip 210 has an active surface 210a and an inactive surface 210b. The active surface 210a is formed with a plurality of power pads 211a, ground pads 211b and I/O pads 211c. The active surface 210a is further formed with a power plane 212a and a ground plane 212b, wherein the power plane 212a is electrically connected to the power pads 211a by a first set of bonding wires 241 (shown in FIG. 2B), and the ground plane 212b is electrically connected to the ground pads 211b by a second set of bonding wires 242 (shown in

FIG. 2B). Besides the use of wire-bonding technology, other electrical connection methods, such as TAB (Tape Automatic Bond) technology, are also suitably adopted for electrically connecting the power plane **212a** and the ground plane **212b** respectively to the power pads **211a** and the ground pads **211b**.

5 The power-connecting heat spreader **220** and the ground-connecting heat spreader **230** are each an integrally-formed piece of electrically-and-thermally conductive material, such as copper.

10 The power-connecting heat spreader **220** includes a support portion **221**, an overhead portion **222** supported on the support portion **221**, and a downward-extending portion **223** protruding downwardly from the overhead portion **222**. The overhead portion **222** is formed with an opening **224**, and sized in area to be equal to or slightly larger than the chip **210**. And, the support portion **221** is formed with a plurality of mold-flow openings **225**.

15 The ground-connecting heat spreader **230** includes a support portion **231**, an overhead portion **232** supported on the support portion **231**, and a downward-extending portion **233** protruding downwardly from the overhead portion **232**. The overhead portion **232** is sized in area to be equal to or slightly larger than the overhead portion **222** of the power-connecting heat spreader **220**. And, the support portion **231** is formed with a plurality of mold-flow openings **234**.

20 Referring FIG. 2B, the next step is to mount the chip **210** on the front surface **200a** of the substrate **200**, wherein the power plane **212a** is electrically connected to the power pads **211a** by the first set of bonding wires **241**, and the ground plane **212b** is electrically connected to the ground pads **211b** by the second set of bonding wires **242**. And, a third set of bonding wires **243** are formed for electrically connecting the I/O pads **211c** on the chip **210** to the I/O vias **201c** of the substrate **200**.

25 Referring further to FIG. 2C, the power-connecting heat spreader **220** is mounted over the front surface **200a** of the substrate **200** to entirely cover the chip **210** in a manner that, the support portion **221** is electrically bonded to the power vias **201a** of the substrate

200, and the downward-extending portion **223** is electrically connected to the power plane **212a** on the chip **210**, allowing the overhead portion **222** to be elevated in position above the chip **210** by the support portion **221** and the downward-extending portion **223**, and not to interfere with the bonding wires **241**, **242**, **243**.

5 Referring to FIG. 2D, the ground-connecting heat spreader **230** is mounted over the front surface **200a** of the substrate **200** to entirely cover the chip **210** in a manner that, the support portion **231** is bonded to the ground vias **201b** of the substrate **200**, and the downward-extending portion **233** penetrates through the opening **224** of the power-connecting heat spreader **220** to be electrically bonded to the ground plane **212b** on the chip **210**, allowing the overhead portion **232** to be elevated in position above the power-connecting heat spreader **220** by the support portion **231** and the downward-extending portion **233**.

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15 Referring to FIG. 2E, a molding process is performed to form an encapsulation body **250** that encapsulates the front surface **200a** of the substrate **200**, the chip **210**, the power-connecting heat spreader **220**, and the ground-connecting heat spreader **230**. During molding, a molding compound used for forming the encapsulation body **250** would flow through the mold-flow openings **225**, **234** at the support portions **221**, **231** of the power-connecting heat spreader **220** and ground-connecting heat spreader **230** respectively, whereby the chip **210** can be assured to be entirely encapsulated by the molding compound. It is preferable to adapt the overhead portion **232** of the ground-connecting heat spreader **230** to be exposed to outside of the encapsulation body **250**, thereby helping increase heat-dissipation efficiency for the package structure.

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25 Then, a plurality of solder balls **260** are implanted on the back surface **200b** of the substrate **200**, including power balls **261** electrically connected to the power vias **201a**, ground balls **262** electrically connected to the ground vias **201b**, and I/O balls **263** electrically connected to the I/O vias **201c**. This therefore completes the fabrication of the BGA package of the invention.

By the above fabricated package structure illustrated in FIG. 2E, power can be externally supplied to the chip 210 successively via the power balls 261, the power vias 201a, the power-connecting heat spreader 220, the power plane 212a, the bonding wires 241, and the power pads 211a. Moreover, the chip 210 can be connected to ground successively via 5 the ground pads 211b, the bonding wires 242, the ground plane 212b, the ground-connecting heat spreader 230, the ground vias 201b, and the ground balls 262. Further, the chip 210 can transfer I/O signals via the I/O pads 211c, the bonding wires 243, the I/O vias 201c, and the I/O balls 263.

Besides power transmission and grounding effect, the power-connecting heat 10 spreader 220 and the ground-connecting heat spreader 230 also help enhance heat dissipation for the packaged chip 210, and thus improve overall heat-dissipation efficiency of the package structure.

Compared to the package structure in the prior art of FIGs. 1A-1B, the BGA package of the invention has the following advantageous.

15 First, as the ground-connecting heat spreader 230 of the invention is arranged to entirely cover the chip 210, it can provide better EMI (electromagnetic interference) shielding effect for allowing the chip 210 to improve its electrical performance during operation.

Further, as the overhead portion 232 of the ground-connecting heat spreader 230 of 20 the invention is exposed to outside of the encapsulation body 250 that encapsulates the chip 210, better heat-dissipation efficiency is effected for the BGA package of the invention.

Moreover, as the power-connecting heat spreader 220 of the invention entirely covering the chip 210 is sized to be much larger than the prior art of using a power-25 connecting heat spreader only covering part of a chip, thereby power from an external source can be more efficiently supplied to the chip 210 in the invention.

The invention has been described using exemplary preferred embodiments. However, it is to be understood that the scope of the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements. The scope of the claims, therefore, should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

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